Assessments of the values of multi-species grassland for grazing, silage and hay production

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Abstract

Different grassland utilizations are possible: direct utilization by animals (grazing) or forage harvest and conservation (either by ensilage or hay). The grasslands value for these different utilizations depends on many variables of the vegetation. These variables can be aggregated to propose scores for the grazing, ensilage and hay. We developed and used these indicators on four annual mixtures from the seed company FERTIPRADO® set up in south of France. Each of these mixtures is composed of 6 legumes and 2 grasses and managed with no irrigation and no nitrogen fertilizer. Botanical composition, height, and nutritional contents, measured using near infrared spectrometry (NIRS) directly on the sward, were monitored every two weeks. From these variables, indicators were developed using the aggregation tool: TATALE. With TATALE, the input variables are first transformed into scores between 0 and 1 and secondly these different scores are aggregated to obtain summary scores. The parameterization (transformation and aggregation parameters) was made by expertise and literature surveys.

These tools provide scores for grazing, silage and hay production values of grassland based on the vegetation state. To illustrate these results, we compared the evolution of one of the four mixtures during the season.

Keywords: multi-specific sward, forage quality, assessment tools

Introduction

Agronomical value of grasslands relies on the quantity of biomass produced and the qualities of the forage. The quality of forage is generally described by several criteria: The protein content and energy concentration and the digestibility. The quantity and the quality of the forage change during the season. Furthermore, the assessment of the agronomical value may also depend of the way the grassland is used. Indeed, farmers can use grassland to feed their animals in different ways: The animals can directly graze the forage or the grass is mown by the farmers. The mown grass can be stored according to two processes: silage or hay. For a given sward, its values for the different uses could be different. A tall sward is less suitable for grazing (animals are not able to eat the tall plants). However a tall sward is interesting for mowing and hay (more standing biomass).

In this paper, we will propose a method to develop indicators to evaluate the value of grasslands for the different uses: grazing, ensilage and hay. We develop and test these indicators on the legume rich mixtures proposed by FERTIPRADO Corporation. The work presented here is a work in progress.

Materials and methods

In the Melgueil experimental site (close to Montpellier, south of France), we tested in 2013, four mixtures proposed by the seed company FERTIPRADO®. These mixtures of 8 annual species were rich in legumes (6 species). The grasslands were managed with only phosphorus and potassium application and with one cut during the year. Every second week, the botanical composition and the height of the grass were assessed. NIRS were used on the standing vegetation to assess the chemical composition (digestibility, fibre and nitrogen content). At the end of the season, the yield was measured. We assumed that the

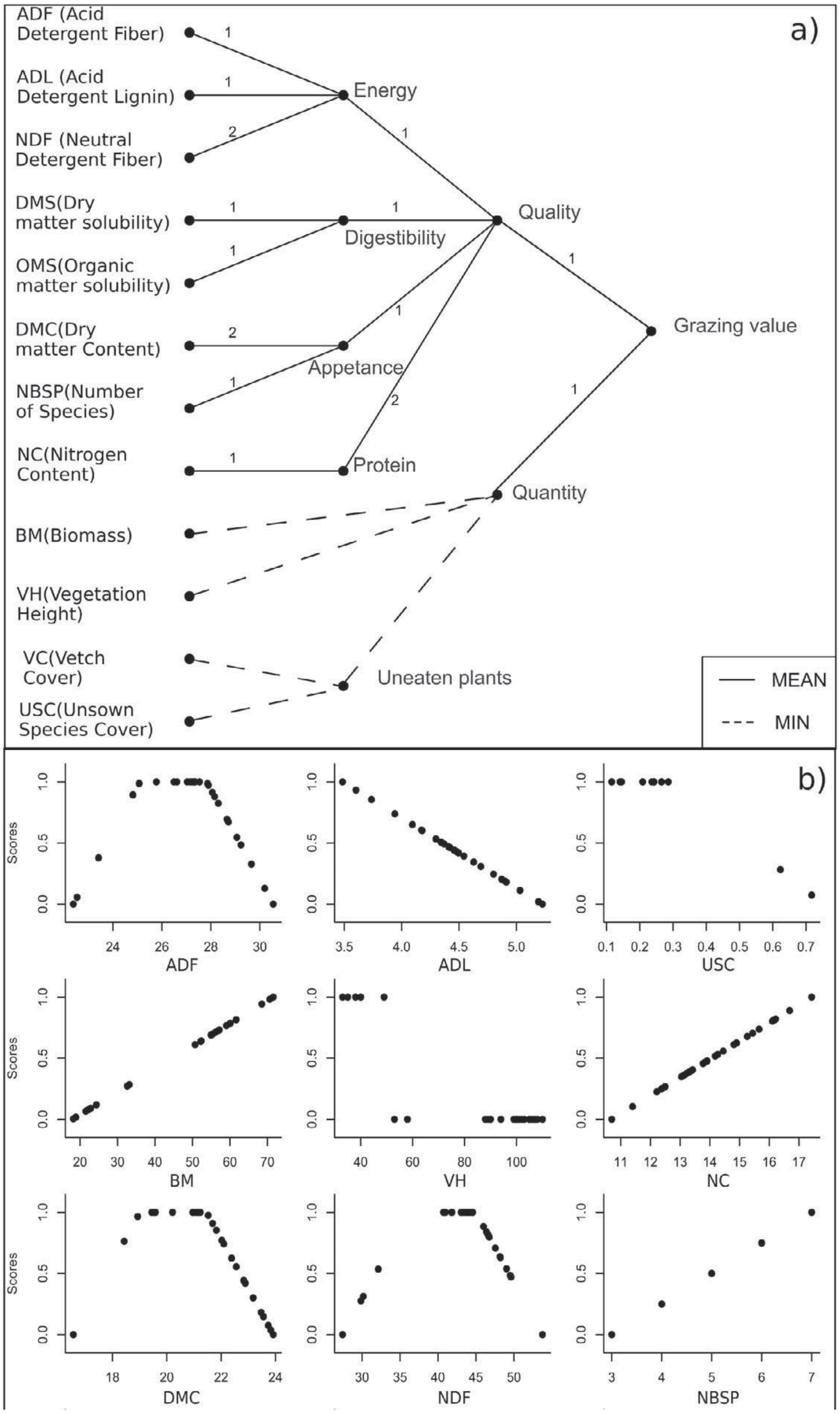

Figure 1. (A) Aggregation tree for the grazing value of grassland. The number represented the weight use in the mean aggregation; (B) Representation of the transformation used for the input variable of the grazing indicators.

biomass and the vegetation height were proportional, and we made also an estimation of the biomass every two weeks using the height of the vegetation.

To assess the values of the different grassland uses, we used a multi-criteria analysis tool: TATALE (Tools for Assessments with Transformation and Aggregation using simple Logic and Expertise); for more information see http://umr-selmet.cirad.fr/en/products-and-services/proposed-products/tatale. The first step of TATALE entails converting all variables into scores ranging from 0 to 1. These scores are then aggregated in the second step. Different methods can be used to aggregate these scores. The scores can be aggregated by a weighted average (the expert can put different weight on the different scores). The other methods to aggregate are to choose one of the scores either the highest score (maximal) or the lowest scores. The aggregation can be successive. Some of the score are first aggregated to create new scores. These new scores are then aggregated together and so on until a single synthetic score is obtained. These processes are repeated for grazing, ensilage and hay. Elaboration of the indicators was discussed and achieved during a meeting with all the authors of the paper.

Results and discussion

Figure 1a presents the aggregation tree for the grazing value. This shows how we aggregated the different scores transformed from the measured variables (in black) into the different synthetic scores (in grey). The grazing value relies on the quality and the quantity of forage. For the quantity, we supposed that not all the standing biomass could be grazed, either because the grass was too short or too tall or because some species were unpalatable. Figure 1b presents the transformation used for the different inputs variables (in x axis the value of the inputs variables and in y axis the scores attributed). Similar aggregations were done for the ensilage and the hay. Table 1 presents scores for the grazing, ensilage and hay values of four mixtures at various times of season.

This example shows how the values of the different utilizations vary during the season. The grazing values of the different mixtures decreases with the season. However, the decrease is higher for the mixes 1 and 4 than the mix 2 and 3. The ensilage score is higher in middle of April for the MIX 2 and higher in the beginning of May for the mix 1, 3 and 4. For the hay, the highest scores were for the four mixtures in the middle of April. This work proposes an indicator for estimating the value of grassland from a battery of many criteria. This indicator could be used to compared different types of grassland and be used as decision making tools especially to choose adapted mixtures for the implantation of grassland. The TATALE method relatively easily creates complex indicators for research and expertise and provides a possible answer to the problem of selection variables in multi-criteria analysis.

Table 1. Scores for grazing (G), ensilage (E) and hay (H) for four different mixtures at 4 different dates. (0 means the worst value and 1 the best possible value).

Mixture	MIX1			MIX2			MIX3			MIX4		
Use	G	E	H	G	E	H	G	E	H	G	E	H
Beginning March	0.36	0.15	0.31	0.37	0.48	0.31	0.44	0.51	0.36	0.43	0.53	0.38
Middle March	0.28	0.49	0.28	0.28	0.52	0.30	0.33	0.61	0.39	0.28	0.58	0.36
Middle April	0.22	0.45	0.47	0.34	0.78	0.51	0.35	0.47	0.53	0.29	0.45	0.50
Beginning May	0.18	0.63	0.43	0.24	0.64	0.45	0.25	0.67	0.48	0.17	0.65	0.44

Effects of inoculant on the fermentation, microbial composition and aerobic stability of whole crop maize ensiled in big tube

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Abstract

The present study aimed to investigate the effect of inoculant, containing *Lactobacillus buchneri* in combination with homofermentative lactic acid bacteria on fermentation, microbial composition and aerobic stability of the whole crop maize ensiled under field conditions. Whole crop maize was harvested in the dough stage of maturity of grain (at 34% DM of the plant) and ensiled into hermetic plastic big tubes either without additives or inoculated with mixture of lactic acid bacteria strains *Lactobacillus plantarum*, *Entrococcus faecium* and *Lactobacillus buchneri*. The final application rate was 1.0×10^5 cfu g^{-1} forage. Ten replications (big tubes, 1,700-1,800 kg each) were used per treatment. The SAS statistical package was used to analyze the data. Inoculant significantly reduced pH value and significantly increased concentration of acetate. Moulds and yeasts numbers and surface area of the big tubes covered with the moulds were reduced and aerobic stability was improved in the inoculated silage compared to the control silage. Quantities of silage suitable for feeding after 35 days aerobic exposure were significantly higher for the inoculated than the untreated silage.

Keywords: aerobic stability, inoculant, maize, silage

Introduction

Well fermented whole crop maize silage is an important source of dietary energy for ruminants due to the high energy content, but it is often prone to aerobic spoilage. Feeds that have undergone aerobic deterioration, may result in aerobic growth of yeasts and fungi, reduced nutritional value and present hazards to the animals and environment. Lactic acid bacteria inoculants were topical during the last two decades and their potential to improve silage fermentation was widely demonstrated (Muck, 2012). Combining heterofermentative with homofermentative LAB allows active fermentation and gain positive attributes when silages are exposed to air, respectively (Schmidt and Kung, 2010). The current study was designed to examine the effect of silage additive containing homofermentative LAB strains *Lactobacillus plantarum*, *Entrococcus faecium* and *Lactobacillus buchneri* on fermentation, DM loss, aerobic stability and microbial population of whole crop maize ensiled into a hermetic plastic big tube.

Materials and methods

Maize (*Zea mays*), was harvested and chopped in the dough stage of maturity of grain, 34% dry matter (DM) of whole plant with a maize harvester 'CLASS JAGUAR 840' adjusted to achieve a 10 mm theoretical chop length. Immediately after harvesting, the chopped forage was carted from the field to the ensiling and storage area and was ensiled into a hermetic plastic big tube (1.700-1,800 kg each), using Murska tube bagging equipment with a loading tunnel can and additive applicator. The following treatments were applied to fresh forage: control no additive and inoculated with homofermentative and heterofermentative LAB inoculant containing *Lactobacillus plantarum*: *Entrococcus faecium*: *Lactobacillus buchneri* – 20:30:50 (Chr. Hansen, Horsholm, Denmark; the stated total number of bacteria was 1.3×10^{11} colony forming units g^{-1} (cfu g^{-1}). The inoculant was applied at rate of 4 liter suspension per tonne forage according to the label instructions for application targeting a dosage of 1.5×10^5 cfu g^{-1} of fresh forage. To compensate for the water that was added to the treated silage, the control treatment (C) was sprayed with 4 l of tap water over a ton of fresh material to keep it at the same level of moisture as the treated silages. During the filling of the plastic big tube, one control bag (made from four layers cheesecloth) filled with 1 kg ensiling mass was inserted into each big tube for determining DM losses. Ten hermetic plastic big tube silages for each treatment were prepared. From each tube and treatment a core sample was taken at day 156 of storage for chemical and microbial analyses and for aerobic stability test. After storage period of 156 days, the big tube silages were subjected to an aerobic stability test at field conditions. The SAS statistical package was used to analyze the data. Silos were analyzed as a randomized complete block.

Results and discussion

Based on the dry matter content (339.6 g kg^{-1}), water soluble carbohydrates (88.3 g kg^{-1} DM) and crude protein concentrations (98.7 g kg^{-1} DM), and buffer capacity (20.6 mEq 100 g^{-1} DM) the whole plant maize was considered to be moderately easy to ensile. Inoculation accelerated fermentation, as identified by the lower (P<0.05) pH at day 2 after ensiling compared with the untreated control. Lower pH of the inoculant treated silages remained until day 156 of the storage (Table 1).

Inoculation with the blend of bacterial strains resulted in silages with higher (P<0.05) concentrations of acetic acid and lower lactic-to-acetic acid ratios. These results suggest that the fermentation in the inoculated silage was dominated by heterolactic *Lactobacillus buchnery* bacteria (Arriola *et al.*, 2011). Inoculated silages had lower numbers of yeasts and moulds at the time of removing of the plastic cover (day156 of the storage) compared with the control silages (Figure 1). However, during aerobic exposure

Table 1. Fermentation characteristics of big tube whole crop maize silages after 156 days of storage (n=10).

Parameters	Control	Inoculated	SEM	*P*
DM losses, g kg^{-1} DM	87	74	3.057	0.05
DM corrected for volatiles, g kg^{-1}	329	334	1.031	0.05
pH day 2	4.00	3.65	0.042	0.05
pH day 156	3.73	3.60	0.022	0.05
Lactic acid, g kg^{-1} DM	33.4	36.5	0.906	ns
Acetic acid, g kg^{-1} DM	17.1	20.3	0.532	0.05
Butyric acid, g kg^{-1} DM	0.50	0.30	0.048	0.05
Ethanol, g kg^{-1} DM	5.80	5.30	0.330	ns
Ammonia N, g kg^{-1}total N	32.7	31.0	1.141	ns
Aerobic stability, hours	100	168	7.853	0.05

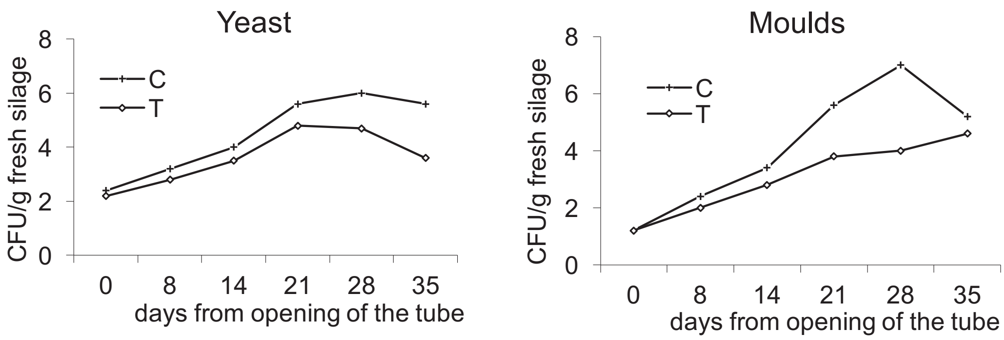

Figure 1. Changes in yeast and moulds count during aerobic exposure of silages under field conditions. C = control, no inoculant; T = *Lactobacillus plantarum*, *Entrococcus faecium* and *Lactobacillus buchneri.*

(at day 8, 14, 21, 28 and 35 after removing of the plastic cover) the number of yeasts and moulds increased more rapidly in the control silages than in the inoculated ones. The highest differences of yeast and mould counts between the control and inoculated silages were found at day 28 of aerobic exposure (5.99 vs 4.72 $\log_{10}$ cfu g^{-1} for the yeasts and 6.95 vs 3.99 $\log_{10}$ cfu g^{-1} for the moulds), which indicated that yeasts and moulds were effectively inhibited by the inoculant. Ström *et al.* (2002) showed the ability of a *Lactobacillus plantarum* strain to inhibit or change the morphology of selected fungi, due to antifungal cyclic dipeptides. Mari *et al.* (2009) indicated that the numbers of yeasts were lower in the silage treated with an inoculant versus the silage without inoculants. Inoculated silages had more hours to reach temperature more than 3 °C above the ambient, therefore, the aerobic stability of inoculated silages, on average, was greater than 68 hours compared with the control silages. Quantities of silage suitable for feeding after 35 days aerobic exposure were significantly higher for the inoculated than the untreated silage.

Conclusions

Inoculant containing *Lactobacillus buchnery* in combination with *Lactobacillus plantarum* and *Entrococcus faecium* gave more heterolactic type of fermentation, produce more acetate, reduced the number of yeast and moulds and improved aerobic stability.

Acknowledgements

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Assessment of multiple ecosystem services of Norwegian semi-natural grasslands based on vegetation characteristics

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Introduction

- Ecosystem services are the benefits humans obtain from ecosystems. Semi-natural grasslands provide multiple services to different beneficiaries: livestock breeders (forage production…), farmers (pollination…), the local inhabitants(aesthetic value…) and the whole humanity (carbon sequestration…).
- Most of these services are related to some descriptors of the vegetation (taxonomic and functional diversity, mean value of functional traits, functional group abundance).
- ➢ We present a simple method to develop indicators of services from vegetation descriptors and assess the trade-off between services.

Studied Services

Benefits	Services
Forage Production	Quantity, Quality, Resilience of forage production
Agricultural Support	Nitrogen fertility, Pollination
Local Wellbeing	Aesthetic , Allergy Control , Pollination
Humanity Challenges	Genetic resources, Carbon Sequestration

- Selection of vegetation descriptors based on literature
- Calculation of the descriptors on 112 plots of grasslands
- Assessment using a simple method (TATALE)

Transformation

- Transformation of the variables into scores between 0 and 1.
- Transformation based only on trends (linear increase) and the dataset of the descriptors

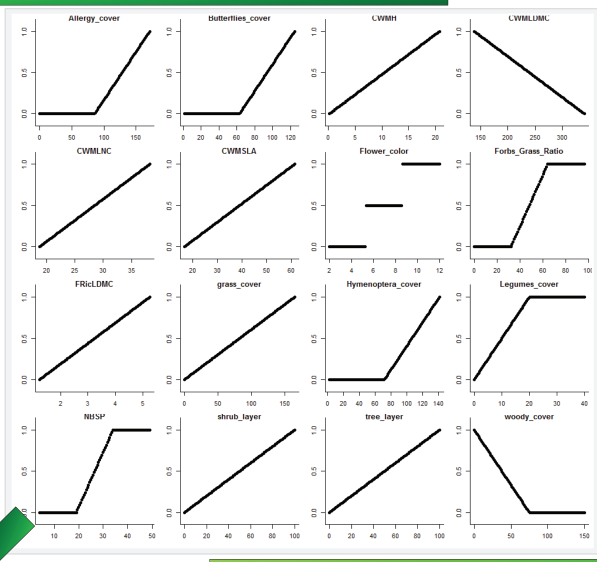

Figure 1: Transformation of the vegetation descriptors into scores between 0 and 1(see Table of abbreviation bellow)

Abbreviation	Description
Allergy_cover	% of species with allergen
Butterflies_cover	% of species with Butterflies pollination
CWMH	mean value of height
CWMLDMC	mean value of LDMC
CWMLNC	mean value of LNC
CWMSLA	mean value of SLA
Flower_color	number of flower colors
Forbs_Grass_Ratio	Forbs/grass ration
FRicLDMC	Range of LDMC
grass_cover	% of grass
Hymenoptera_cover	% of species with Hymenoptera pollination
Legumes_cover	% of legumes
NBSP	number of species
shrub_layer	% of shrub
tree_layer	% of tree
woody_cover	% of woody species

Aggregation

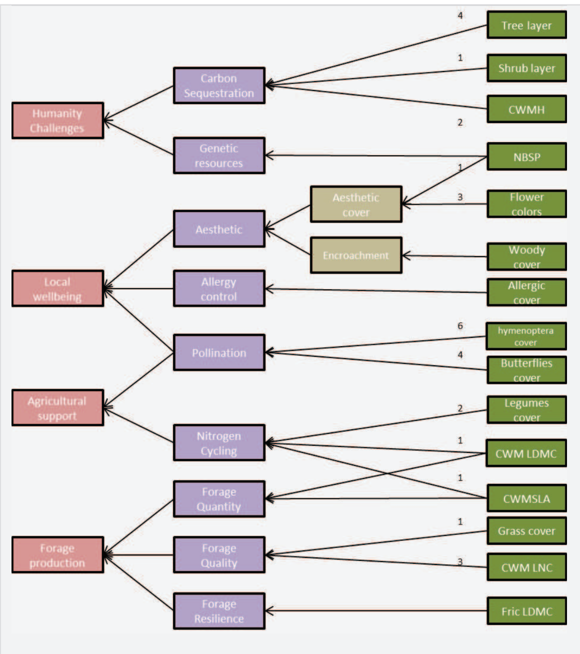

Figure 2: Aggregation tree The scores are aggregated progressively using the weighted average of the scores

Conclusion

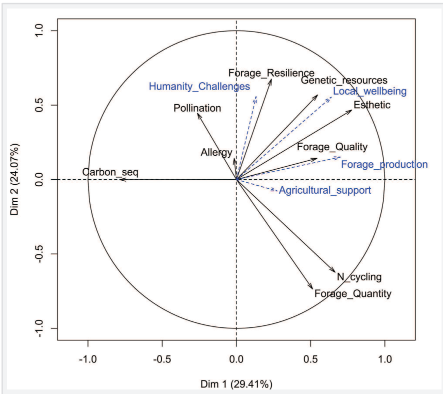

Figure 3: PCA on the outputs of the tree(trade-*offs)

- **Simple method**
- **Useful to compare multiple services**
- **More expertise needed to create the indicators**

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